# Collective Capability in Multi Agency Services

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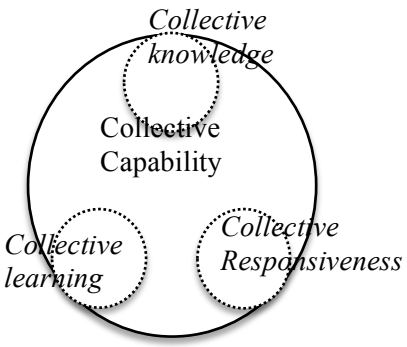
This paper develops a conceptual framework for supporting the development of systems to support Collective Capability (CC) in Multi Agency Services (MAS). In particular it develops a conceptual basis for Human-Agent collaborations in multi organization federations developing and delivering services and providing a joined up collective capability. In that context a further crucial aspect of this conceptual framework is in ensuring situational awareness (SA) is achieved within a multi-organization federation. In the paper we further address the need for situational awareness and introduce the concepts of knotworking and relational agency as mechanisms for achieving SA in MAS. In addition a yet further significant feature is that of the need for the CC of the MAS to continually learn and to deliver self-organization of services in multi-organization federations. In this context we develop the concept of expansive learning. Together these concepts provide a conceptual framework to support CC in MAS. Here we follow Engeström et al. (1999) who developed the concept of knotworking to describe the "construction of constantly changing combinations of people and artefacts over lengthy trajectories of time and widely distributed in space" (p. 345). Whereas the notion of expansive learning embodies the idea of learning what is not yet there. Rather than learning the existing rules in a setting it is learning or creating new understandings. In the settings of inter-professional activity which concern us relational agency is a capacity for fluid and responsive work. It involves working with others to recognise and respond to what matters for each profession in complex professional activities.

MAS failures cause ineffectiveness and inefficiency, and cost both lives and resources e.g. as seen in 'Baby P', '7/7', '9/11' and Hurricane Katrina. In the contexts of defence and security situations there are often multiple groups the military have to work with (i.e. military allies, community, police, government, adversary groups) who all have multiple goals as well as having to take into account the various cultural differences influencing and effecting those goals. Challenges include, lack of cross-service collaboration, agility and responsiveness. Effective MAS requires agile and flexible solutions in the face of complex and rapidly changing situations. We characterise the underpinning challenges in terms of three types of information flow and knowledge creation failures: 1. Codesign of Responsive services, by service agencies and users; 2. Collaborative Knowledge Sharing across service agencies to establish common knowledge; and 3. Strategic Learning between multiple service strategists, policy makers and deliverers to ensure agile systemic response. Underlying these information flow and knowledge creation failures are generic problems with data, models and inferences. Current technologies have failed in many respects – being unfit for purpose, not providing the right information at the right time, causing information overload and in-effective working in large service agencies (e.g., military, health services). ICT in MAS is often rule bound, good for ensuring compliance but enforcing rigidity and inflexibility. Moreover, these rules are not shared across all groups and communities and ignore the informal, social, customs and values. Consequently, people find "work arounds" or hide their "rule breaking & bending". To overcome these limitations we must identify and explain causal relationships between the complex properties of MAS that allow us to develop and assess revolutionary technologies to collect, represent, share and manipulate information and create knowledge in dynamic and responsive systems. Collective Capability (CC) is created when disparate groups and individuals share information and knowledge, collaborate and develop relational agency. For this to happen there must be cultures and technologies that support responsiveness, working together and learning.

Our vision is to create a science and technology of CC that can underpin the design, building and use of systems to enable collaborative, agile, responsive and efficient MAS. That will enable multiple agencies to work dynamically and smoothly together to provide effective and efficient MAS and prevent service breakdowns. This will require 1.user engagements in multi-agency services (responsiveness), 2. improved common knowledge and 3. Improved specialised knowledge and understanding within and across group interactions (working together), and 4. learning within and across strategic and operational aspects of practice. This will be realised through collaborative technologies and practices that together provide a collective capability approach to delivering MAS that are valued, timely and relevant to the needs of people and situations. This paper investigates Collective Capability (CC) through three conceptual themes –

- collective responsiveness (CR),
- collective knowledge (CK) and
- collective learning(CL).




In other words it relates to data collection interpretation and inference technologies (CR), knowledge sharing and knowledge representation technologies (CK); technologies for learning (CL)

***Collective Responsiveness*** requires collective decision-making, co-design, adaptation and personalisation This involves decision-making using mathematical system modelling alongside human individual and collective judgements developing software tools as collective decision-making aids for service providers. It must enable strategic and operational flexibility in decision-making, developing decision-making software layers for rapid recording "apps" that utilise sensor networks to allow the user to easily record novel strategic and operational decision taking. It must avoid regression to the mean in collectives, developing social networking tools for co-creation of knowledge and services.

***Collective Knowledge*** requires knowledge representations, access and assessment support collaborative knowledge building through data/information/knowledge collection /refinement processes, with software processes for real-time multi-user data/information/knowledge collection/refutation/refinement. There must be personalised, contextually relevant representation of collective knowledge, with software tools and representations that personalise collective knowledge to the individuals needs, contexts and platforms. In addition there will be collective knowledge structures (semantic, pragmatic and event based) supporting multi-faceted knowledge gathering and mining tools to access and manipulate collective knowledge structures.

***Collective Learning*** requires knowledge creation, restructuring, generalisation and transfer. This raises the trust, privacy and security issues that support collective learning. Addressed through providing large-scale simulations for probabilistic models to predict and learn trust/privacy/security properties. It further requires the spread and growth of learning within and across agencies from individual to whole. Delivered through scale-free networks which form the basis for emerging spread and growth leading to Collective learning. A further requirement is to make trade-offs between "rule breaking" and learning through developing safe environments that encourage and facilitate experimentation and analysis of solutions to problems. Acts of rule breaking and micro acts of defiance are interesting as they indicate stress points and indicate how people get around rigid systems or use systems in unintended ways to get results. Also, if there are uniform 'work arounds" these can then be incorporated into a structured evolutionary approach of Collective Learning.

**Two Case Studies of Multi-Agent Systems and their Current Working**

***Case study One: Emergency and disaster relief*** In the case of emergencies on the scale of disasters such as hurricane Katrina and more recently the Fukushima nuclear power plant crisis both military and civilian groups work closely together with each other and the local community to respond to the emergency and bring about a safe and stable situation. There are significant challenges and issues with the current way that these agencies work. In both the case of Katrina and Fukushima there are rich examples of failures in the agencies involved to

- work together
- recognise when ways of working were creating problems
- develop new ways of working
- act responsively and in ways appropriate to the needs

***Fukushima***

First let's consider Fukushima, Daiichi Nuclear Power Station (NPS) in Fukushima, Japan was struck with an earthquake and tsunami. This resulted in a nuclear emergency that was made worse by communication gaps between the government, nuclear industry and the general public. First a (very) brief overview of events:

March 11 14:46 9-0 earthquake. Nuclear Power Station automatically shuts down.
March 11 14:48 Power Substation out of service.
March 11 15:27 Tsunami 1.
March 11 15:35 Tsunami 2 .
March 11 15:32 Station Blackout (whiteboard memo).
...Emergency Diesel Generators rendered inoperable due to flooding in basement...
March 12 15:00 power connected.

March 12 15:36 Hydrogen Explosion(s) Unit 1 loosing containment.
March 14 11:01 Hydrogen Explosion Unit 3 loosing containment.
March 15 6:00-6:10 Hydrogen Explosion Unit 4 loosing containment.

Now let's look at a very specific and interesting event that occurred:
***Yoshida ignores command and continues to pump seawater.***
Following the earthquake Yoshida, the site-head, pumped seawater into the NPS reactor to prevent the core from overheating. Around 12:00 Yoshida decided to make preparations to start a seawater pump and ordered an in house fire-fighting team to start to research the configuration for a line configuration or seawater injection (Committee, I. 2011). At this point, apparently, no one at TEPCO HQ was opposed to injecting seawater. When the NPS ran out of freshwater at 14.53 March 12th (AJW, T.A.S 2011), it needed to start pumping seawater into Unit 1(Committee, I. 2011) in order to cool the reactor. Such an important decision normally requires the president of the Tokyo Electric Power Company (TEPCO) to sign off on it (AJW, T.A.S 2011). The start of the seawater pump was approved by TEPCO president Masataka Shimizu. At around 14:54, Yoshida ordered the seawater to be pumped into the Unit. (Committee, I. 2011). At around 15:18, Yoshida reported to government bodies that they would start injecting seawater once freshwater supplies were gone (Committee, I. 2011). Kan asked about the criticality of the damaged fuel in unit 1 reactor that may result from pumping seawater. The chairman of the nuclear safety commission, Madarame, replied that after sea water injection such a possibility "could not be denied" (Funabashi, Y., Kitazawa, K 2012). Therefore the decision to continue pumping seawater became difficult. As a result, TEPCO company chief Tapekuro was liaising with the government notified the TEPCO head office that further water injection should be avoided until the government had decided on a course of action (Funabashi, Y., Kitazawa, K 2012). TEPCO president Shimizu communicated this to Yoshida on-site (via teleconference (AJW, T.A.S 2011)) at the nuclear power plant. The decision was made to stop pumping seawater. Yoshida insisted on restarting injections as soon as possible (Funabashi, Y., Kitazawa, K 2012).
"During a teleconference, Yoshida called the employee in charge of the seawater injections to his side and whispered in his ear so the microphone for the teleconference with the head office would not pick up his voice that though he would now order a halt to the seawater injections, the employee should disregard the order and continue. Thereupon, Yoshida loudly declared to all teleconference participants that water injections would be interrupted." (Funabashi, Y., Kitazawa, K 2012)".
This was possibly to avoid any further confrontation with the government. At this point the on-site workers were going directly against instructions from their HQ. Kan instructed the seawater to resume pumping at 8:20pm (AJW, T.A.S 2011). However, the pumping of seawater had never stopped.
Now let's consider another dimension of the events of Fukushima with respect to developing and adopting alternative technologies.
***Crowd Sourced Radiation Detection***. The Japanese government's radiation detection system, SPEEDI, predicts local radiation levels (Chino, M., Ishikawa, H., Yamazawa, H.,1993). Information concerning radiation levels, provided by SPEEDI was withheld from the general public. The reports produced by the system were sent to Japan's nuclear safety agency. However, the reports were not acted upon. Consequently, a school predicted to receive dangerous levels of radiation was turned into an evacuation shelter. Due to a lack of trust in official reports the general public in Japan felt there was a growing need to take matters into their own hands. Crowd-sourced geiger counter readings from all over Japan were and are still being aggregated on the Pachube platform online (Courtland, R ,2011) (now called Cosm - Developers, C.: https://cosm.com/). The Cosm platform works by allowing users to collaborate in many ways, including (i) build and connect their own devices, (ii) control, monitor, analyse data, (iii) search for other devices, (iv) browse and search data to find out what is happening, and (v) build communities and conversations around data. Websites such as Safecast (Safecast Team: http://blog.safecast.org/about/) allow users to submit their own readings and view their readings alongside others'. The aim of Safecast is to "empower people with information about their environment" (Safecast Team: http://blog.safecast.org/about/). Individuals have generated maps based on the data. For instance, Kalin Kozhuharov generated a map displaying mobile data using google fusion tables (Kozhuharov, K., 2011). Also, Lionel Bergere created an interpolation map that uses existing geiger counter readings and attempts to fill in the space between individual readings (see: http://gamma.tar.bz/maps/static/).

In these reports from Fukushima we can see the challenges and failings that the government and industrial agencies experienced. The lack of shared awareness across the plant operatives, the company officials and

the government officials resulted in conflicting commands, commands not being obeyed together with reporting failures. Similarly, the reliance upon central data collection and information distribution resulted in inaccurate and un-trusted information about radiation levels. This resulted in the appropriation of an emergent technology by individuals becoming the trusted and relied upon source.

***Katrina***

Hurricane Katrina was one of the costliest natural disasters to strike the United States in recent years. The total property damage is estimated at $81 billion and at least 1,836 people lost their lives. The rescue missions that took place following the events were subdivided into search, rescue, evacuation, supply and delivery. Temporary organizations were created and the command structure is both dynamic and readjusted to the events as they unfold and also must not interfere with already
established command structures. This is based on the description of the events as given by James Moffat in "Modelling and Simulation for Network Enabled Operations" and the report "A failure of Initiative" US House of Representatives 15th February 2006 (see: *http://www.disastersrus.org/katrina/USHousereport.pdf)*. Moffat (page 86) reports;

"One day after landfall, on 30th August 2005 the Joint Task Force (JTF) Katrina was established. States forwarded their requests for assistance to federal civilian officials, and these requests then moved through a series of military channels. Inherent in this process was the need for time to assess the capabilities required by each request and to design an appropriate military response. There was, at this early stage of events, an incorrect situational awareness and understanding at the DoD level. Civilian and military decision-makers throughout the government apparently judged that the projected flow of National Guard units would be sufficient. Only on the 30th of August did the Deputy Secretary of Defense give the commander in charge a "blank cheque" for any DoD resources, and on 31st August a high level military officer still "did not believe that federal ground forces were needed."

Moffat continues…(page 87);

"Federal military forces lacked situational awareness of which National Guard units were in the area and how they were operating. The command of the National Guard units and the federal level could not exchange information due to incompatible communication systems. No unified command system was put in place during the search and rescue, evacuation, and supply delivery missions. The effect was that of having multiple rescue teams operating in the same area while other areas were left uncovered. This is an example of *conflicted command*, and occurred over the first week after landfall, from 29th August to approximately 4th September. At the initial stage then, *conflicted command* was in place. Only after some days were National Guard and active-duty units deliberately deployed into different geographic areas where they carried out various relief and rescue missions using separate command structures, increasing the command approach to *de-conflicted command*."

Moreover Moffat reports that the only example what he calls "edge command" (page 89) ie agile responsive behaviour.

"This was the response of an individual pharmacist to the crisis in medical supplies in New Orleans. He raided the flooded pharmacies and repositioned these supplies in local downtown hotels. His rich understanding of the situation led to a local response consistent with the overall intent—saving lives."p89.

These are just some of the reported challenges and failings that the civilian and military agencies were faced with during Hurricane Katrina. The rules, structures and procedures of the different agencies prevented the distribution of information, the formation of collective knowledge and the dearth of agile responsive behaviour. From both of these disaster emergency response case studies we can begin to identify requirements to overcome the shortcomings of the socio-cultural, and working practices of these agencies. We argue that these socio-cultural and working practice requirements carry with them requirements for improved communication, reporting, commanding, and data gathering and knowledge sharing and decision making technologies.

**Case Study two: Local Authorities (LAs) and the Troubled Families programme** LAs face many challenges as they seek to identify and work with 'troubled families'. These families almost always have other often long-standing problems which can lead to their children repeating the cycle of disadvantage. They are defined as households who: are involved in crime and anti-social behaviour; have children not in school; have an adult on out of work benefits; and cause high costs to the public purse (See "The Troubled Families

Programme". Communities and Local Government. Crown Copyright March 2012 *http://www.communities.gov.uk/documents/communities/pdf/2117840.pdf*). At minimum this work will involve agencies concerned with crime, education and employment. However central government is also encouraging LAs to use their discretion to consider with local partners, such as health, police and others what the range of issues is that they will use to prioritise and how to identify the families. These include families: containing a child who is on a Child Protection Plan or with a looked after child; subject to frequent police call-outs or arrests; and those with health problems such as emotional and mental health problems, drug and alcohol misuse, long term health conditions, those caused by domestic abuse and under 18 conceptions. Policy requires LA to take a systematic and strategic approach to these most challenging of families who have concerned different services for years. The first step involves complex and challenging Multi-agency services (MAS) work as the LA compiles a list of families who will be part of the subsequent intervention programme. It also will involve professionals collecting information and sharing it within and between services in order to identify families with complex needs. This involves the collection of sensitive personal data by case-workers with a statutory demand for secure collection, transfer and retention of those data. Current data storage and representations of needs vary across services and have, in the past, proved to be very difficult to share (Edwards *et al*, 2009).

In earlier work on practices of professional learning in and for MAS it was noted that practitioners described taking risks involving rule-bending as responses to contradictions between emergent practices and systems of rules, protocols and lines of responsibility. They demonstrated the need to question the legitimacy of the existing rules in relation to their professional actions on increasingly complex objects of activity and the necessity of making visible the ways in which they worked around the barriers to action. For example, systems of referral which meant that organizations passed on 'bits of the child', as one practitioner put it, from one to the other, were opened up for scrutiny and criticism of how slow the respective organizations were in enabling parallel, inter-professional collaboration which was more responsive to the needs of children. Rule-bending was sometimes observed, reflecting practitioners' frustrations about the responsiveness of systems to new demands of child-centred collaborations. These were likely to be a matter of by-passing organisational hierarchies in order to make direct contact with the practitioner in another service who could help quickly.

**IMPLICATIONS OF THE CASE STUDIES**

So what can we conclude from these very different and very exceptional case studies? While they are very extreme events and very different in their nature, they are the very things that test the capability of our trusted services to act properly when called upon to do so. Those services are intended and strategically planned to be able to cope with and respond to these extreme and serious situations. The procedures, policies and ways of working are there to ensure that they deliver the services that we must rely upon. Consequently, we are very concerned when we find that there are some very common properties of each, that transcend the differences, and which we have observed in further situations. Each of these case studies is an example of what has been termed complex and wicked problems where the nature of the problem itself is never fully understood "sometimes only after the event, as in the case of Baby "Peter (in which the mistreatment leading to the death of Peter by his carers occurred despite repeated visits by various social, welfare, health and other services in the UK) and at other times not even after the event. The nature of each of these case studies, and the nature of complex wicked problems is that a known answer, from a known expert is not appropriate or available since the nature of the problem itself is not understood. Only through the unfolding of attempts to take action is the nature of the problem further disclosed. This brings with it a number of consequences;

1. The failure to notice, report and share what turns out to have been important data. This often occurs through preconceived notions of what is relevant in the individual or the culture and processes of the organisations.
2. The lack of agility and the reluctance or fear of trying something new that is outside the known bounds of practice. This occurs through structural pressures on the individual and organisation, and the lack of a mechanism to sanction, assure or approve such actions.
3. The failure of the whole to learn rapidly during the event. This occurs through rigid and stove-piped lines of communication, false or non-reporting in order to comply, to avoid rebuke, and/or to save time and get on with it.
4. An over reliance upon the formal, established, specialist, resources and processes and an inability to make effective use of the "unofficial", novel, and available. This occurs through the misplaced ownership of the problem being in the hands of a few.

5. The resultant breakthroughs that contribute to solution and future ways of working come from outside the current known expertise, processes, and responsibilities.
6. The mechanisms to, share, question, reflect and propose alternatives are not available to all but a few and often in highly abstracted and prescribed forms. This occurs from the lack of trust, fear of "information overload", the lack of light-weight mechanisms, and the inability to construct "provenance" from novel sources.
7. The nature of leadership and command is often rigid, inflexible and prescriptive. This occurs from a belief that command and leaders must always appear to know the right answer and be the ultimate experts. This results in the suppression of new ideas, improved problem solving, and prevents a culture of empowered discovery.
8. The processes and tools are often inappropriate and inflexible and the ability to appropriate new or changed tools and processes is poor. This occurs from the lack of available easily reconfigured and adaptable tools and processes and the inability to allow appropriation of external tools and processes for fear of "damaging the system".

**Meeting those Challenges**

We hypothesise that new processes and technologies can enable Collective Capability by providing improved creation gathering, representation and sharing of information that enhance:

- *local and global awareness* of individuals, teams and agencies in the collective,
  - enhancing the power and utility of information knowledge sharing,
  - improving the ease of collection, richness and rapid assessment of locally gathered information for global learning.
- *decision-making and decision-making process i.e.*
  - Improving the production and sharing information by individuals and groups,
  - Improve the collective analysis and assessment of that information,

We believe that this will to lead to improvements in MAS collective capability in terms of; improved capability, and greater effectiveness. More specifically, we postulate that greater shared awareness and utility of information, collective analysis and assessment for decision-making will increase the capability and agility of MAS. It is important to note that these effects will also be complex i.e. greater shared awareness will affect collective analysis and assessment for decision making, more collective decision making will in turn lead to greater shared awareness. Collective Capability will produce collaborative, agile, responsive, and efficient collaborative working. To achieve this research must investigate the socio-technological, environmental and contextual factors that support collective capability in MAS. Such research must employ a range of theoretical and methodological perspectives. We argue that much understanding and insight is to be gained from bringing together Activity Theory, Collective Intelligence and Human Computer Interaction theory and methods to understand the interaction between the processes, technologies, the end users, their work and Collective Capability.

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